The High Time Resolution Spectrometer (HTRS) aboard the International X-ray Observatory (IXO)

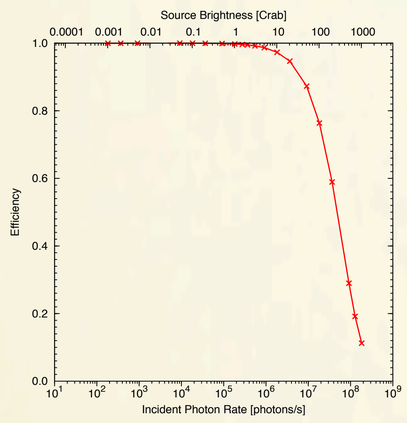
Didier Barret, Laurent Ravera, Carine Amoros, Martin Boutelier, Jean-Michel Glorian, Olivier Godet, Karine Lacombe, Roger Pons, Damien Rambaud, Pascale Ramon, Souad Ramchoun, ***Centre d'Etude Spatiale des Rayonnements (France)*****; Pierre Bodin, Marielle Belasic, Rodolphe Clédassou, Benjamin Pouilloux,** ***Centre National d'Études Spatiales (France)*****; Christian Motch, Laurent Michel,** ***Observatoire de Strasbourg (France)*****, Peter H. Lechner, Adrian Niculae,** ***PNSensor GmbH (Germany)*****; Lothar W. Strüder,** ***Max-Planck-Institut für extraterrestrische Physik (Germany)*****; Eckhard Kendziorra, A. Santangelo, Christoph Tenzer,** ***Eberhard Karls Univ. Tübingen (Germany)*****; Jörn Wilms, Ingo Kreykenbohm, Christian Schmid,** ***Friedrich-Alexander-Univ. Erlangen-Nürnberg (Germany)*****; Stéphane Paltani, Franck Cadoux,** ***Univ. of Geneva (Switzerland)*****; Carlo E. Fiorini,** ***Politecnico di Milano (Italy)*****; Mariano Méndez,** ***Univ. of Groningen (Netherlands)*** **and Sandro Mereghetti,** ***INAF - IASF Milano (Italy)***

Abstract: The High Time Resolution Spectrometer (HTRS) will provide the International X-ray Observatory (IXO) with the capability to observe with >90% throughput bright X-ray sources (up to at least 10 times the Crab intensity, ~2 Mcps) with ~150 eV spectral resolution (at 6 keV) and microsecond time resolution. The instrument will be provided by an international consortium led by CNES and CESR, and involving Germany, Switzerland, Italy and the Netherlands. The HTRS is being currently studied as part of the IXO assessment phase. Here we present the functional and mechanical designs of the instrument, after recalling its top-level requirements, baselined performance and the detector technology used.

HTRS requirements and performance simulations

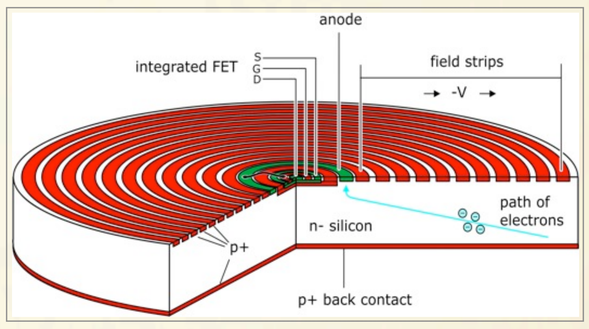
Parameter	Value
Max count rate (nominal)	2 Mcounts/s (~12 Crab)
Energy range	0.3-15 keV
Energy resolution @ 6 keV	<200 eV/150 eV (goal)
Minimum time resolution	10 microseconds
Deadtime @ 1 Crab	<2%
Pile-up @ 1 Crab	< 2%

The HTRS top level requirements for neutron star and stellar mass black hole science: equation of state of dense matter, black hole spins and strong gravity probes.

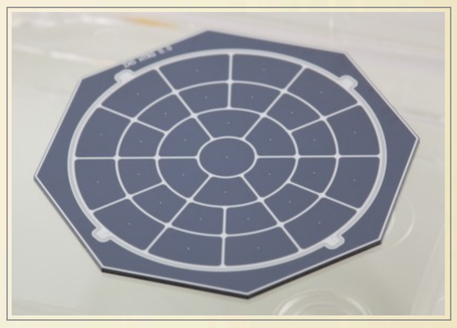


Detector efficiency (fraction of photons counted) as a function of the incident photon rate, computed through analytical modeling and numerical simulations of time variable or constant light curves taking into account the detector geometry and performance of the electronics.

Detector technology

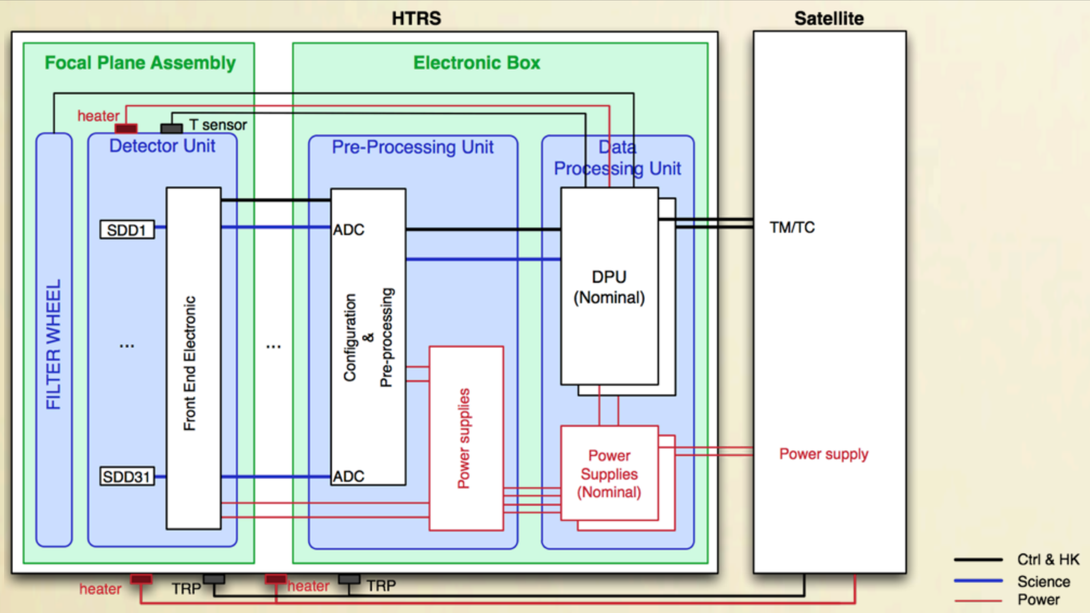


The detector technology for the HTRS is based on Silicon Drift Detectors (SDDs). SDDs have very small capacitance and an integrated JFET, which make them very suitable for high count rate applications. They show low leakage currents and are robust for space applications. Their typical energy resolution is ~140 eV at 6 keV (-20C).



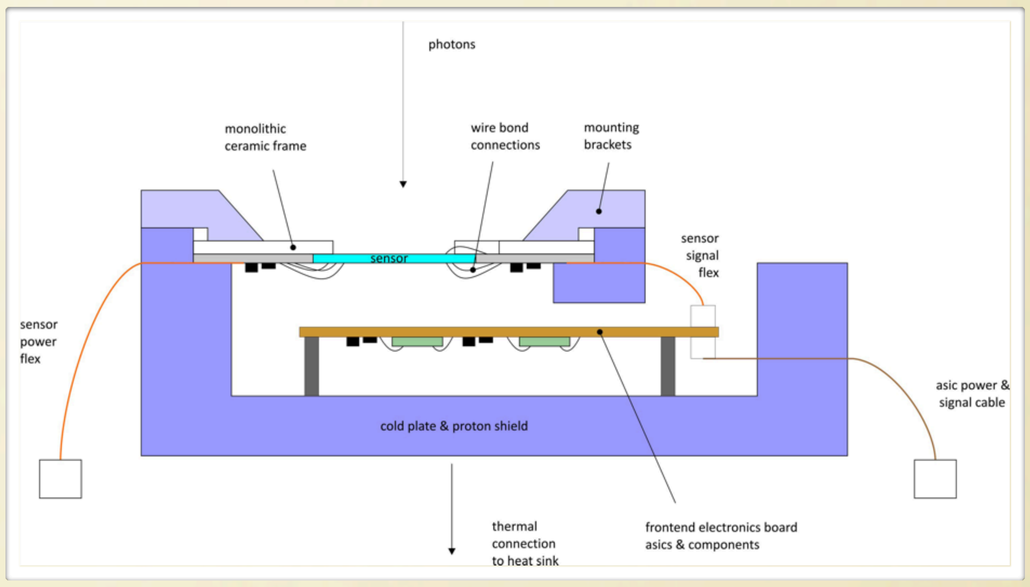
In its current design, the HTRS is an array of 31 SDDs, placed slightly out of focus, in such a way that the focal beam is spread quasi-uniformly over the array. This solution maximizes the performance of the instrument, by increasing its count rate capability.

Functional diagram



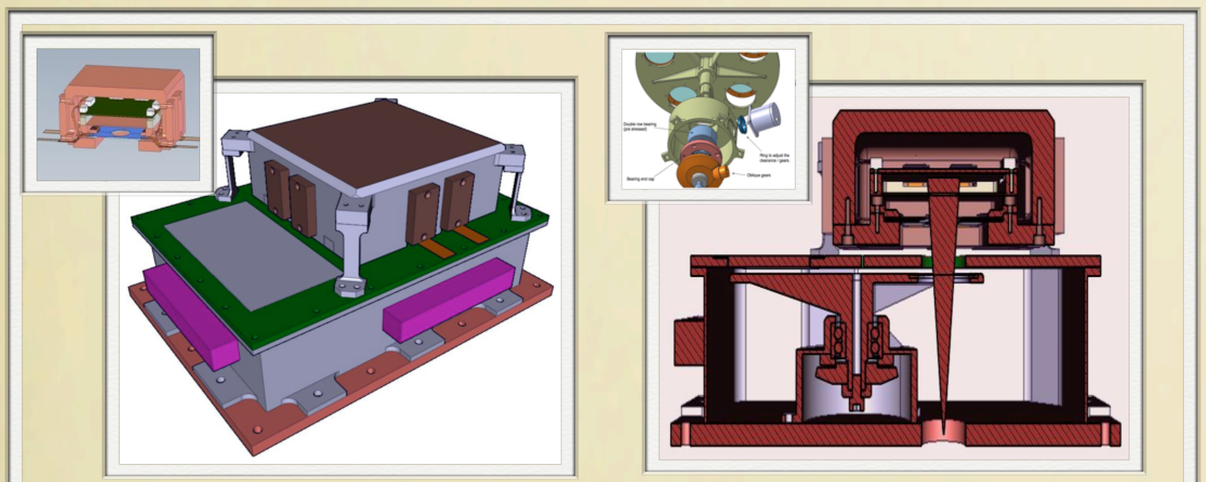
The HTRS is made of two main components: the focal plane assembly (which includes the filter wheel), and the digital electronics, which is divided in two parts: the so-called Pre-Processing Units (PPU, which takes the output of the FEE analog chain), and the Data Processing Unit (DPU whose main functions are the packaging of the science data and the instrument management).

The detector unit



The detector unit includes the detector hybrid, the readout FEE ASIC hybrid, flex interconnections. The SDD array is protected from radiations through a proton shield. The detector will be passively cooled and regulated at -40C.

The focal plane assembly



The focal plane assembly includes the shielded detector unit, the filter wheel and the support structure. The assembly is surrounded by connectors going directly to the electronics box located less than 1 meter away. The filter wheel will have 5 positions (close, open, 2 optical filters, calibration source). It will consist on a single motor operated by two commands (2 coils). The gears and the motor is enclosed to prevent contamination on the cold SDD array.

Dimensions, mass and power budgets

Dimensions	Mass with 20% contingency	Power at peak with 70% DC-DC conversion efficiency & margins
310x230x155 mm^3 (FPA) 360x233x175 mm^3 (electronics box)	30.3 kg	145 W

Conclusions

- The HTRS relies on existing technologies, which all have a high technology readiness level. The mechanical design is frozen, thermal modeling is on-going – performance simulation provide support for design evolution - Mass and power budgets were consolidated along the study.
- The current HTRS design meets the top level mission requirement (<10 % deadtime @ 1 Crab) with very safe margins – no issues were raised during the mid term review conducted by ESA
- The funding in place for HTRS related hardware activities until the end of the assessment phase.

List of fellows supporting the HTRS in IXO: D. Altamirano, A. Baykal, S. Bhattacharyya, T. Belloni, E. Cackett, P. Callanan, D. Chakrabarty, C. Done, K. Ebisawa, M. Gilfanov, E. Gogus, E. Gourgoulhon, J. Homan, W. Hermsen, P. Jonker, E. Kalemnci, Ph. Kaaret, E. Kendziorra, M. van Kerkwijk, M. van der Klis, W. Kluzniak, C. Kouvelioutou, D. Lai, J.P. Lasota, T. Maccaronne, K. Makishima, S. Mereghetti, C. Miller, C. Motch, J.F. Olive, S. Paltani, F. Paerels, I. Papadakis, J. Paredes, J. Poutanen, D. Psaltis, N. Rééa, R. Remillard, M. Revnivtsev, J. Rodriguez, R. Rothschild, A. Santangelo, L. Stella, M. Tagger, J. Tomsick, H. Tsunemi, Y. Uchiyama, A. Watts, R. Wijnands, J. in't Zan't, A. Zdziarski. **To receive informations about the IXO-HTRS, please send an email to Didier Barret (didier.barret@cesr.fr). Thanks.**